CONCEPTUAL FRAMEWORK FOR COMPARATIVE ANALYSIS OF INTEGRATED WATER RESOURCES MANAGEMENTS IN ANDEAN REGION: —A PROPOSAL & CASE STUDY—

SHINJI FUKUDA
Institute of Tropical Agriculture,
Kyushu University, JAPAN
(*JAPAN-CGIAR Fellowship Program 2007-2008*)

WHO IS SHINJI FUKUDA???

- Japanese
- Ecological modelling (fish habitat, paddy environment, agriculture)
- Tropical Agriculture (Vietnam, Laos, Thailand, etc)
- JAPAN-CGIAR Fellowship Program 2007-2008 (two months in CONDESAN/CIP-Lima)

CONTENTS

A) Self-introduction
B) Introduction (*background*, *objective*)
C) Methods (*conceptual framework*)
D) Application (a *case study*)
E) Discussions (*merit & demerit*)
F) Future Perspectives

ANDEAN SYSTEM OF BASINS

Challenge Program for Water & Food:

International, multi-dimensional, research-for-development initiatives

1st Phase: 2003-2008

- La Miel
- Fuquene
- El Angel
- Ambato
- Altomayo
- Jequetepeque
- Tunari

OBJECTIVES

- Developing conceptual framework

➔*Comparison between basins*

  - Evaluation of past project
    - ✓*How much have we achieved?*
  - For the future directions
    - ✓*How far will we go?*

➔ Clarification of key factors for the success

➔*Sharing experiences between basins*

HOW?

- Existing methodology
  - Water Poverty Index (e.g., Sullivan, 2003)

    (Access, Resources, Capacity, Use, Environment)

  ➔Require specific surveys...time consuming...

What are the tools for?

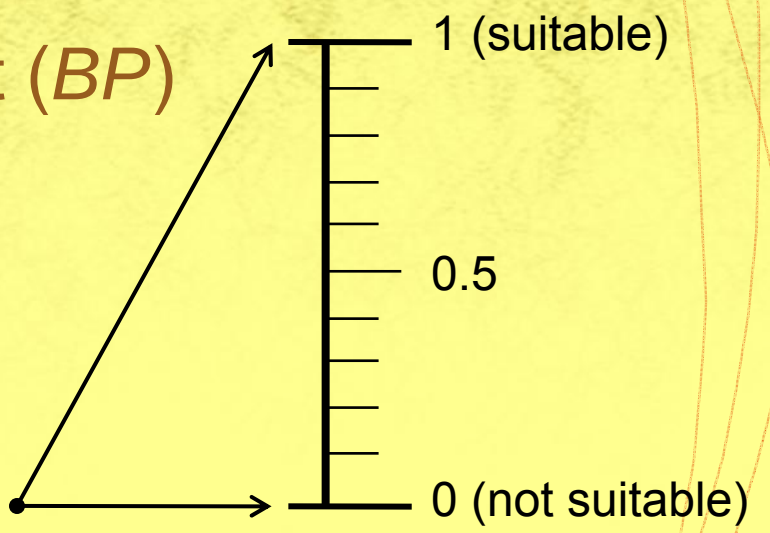
➔ Seeking a future direction (decision-making)

- How to negotiate among stakeholders
- How stakeholders can get closer
- Share image of the past, present, and future

➔Should be simple & generally acceptable

THE PRESENT APPROACH

- Main components
  - ① Biophysical environment (*BP*)
  - ② Agriculture (*AGR*)
  - ③ Socio-economics (*SE*)
  - ④ Ecosystems (*ECO*)
    - Index in the range of [0, 1]



- Integrating components

$$Basin\ Index = I_{BP} \times I_{AGR} \times I_{SE} \times I_{ECO} \quad \text{— (1)}$$

$$Basin\ Index = \left(I_{BP} \times I_{AGR} \times I_{SE} \times I_{ECO}\right)^{1/4} \quad \text{— (2)}$$

BASIC CONCEPT

	Past status			Future Goals	
Component	**10 yrs ago**	**5 yrs ago**	**Present**	**5 yrs later**	**10 yrs later**
Biophysics	○	➔	▼	↗	○ (?)
Agriculture	○	↗	○	➔	○ (?)
Socio-economics	▼	↗	○	➔	○ (?)
Ecosystem	○	↘	▼	↗	○ (?)
TOTAL	▼	➔	○ or ×	➔	○ (?)

Past →→ Present →→ Future

COMPONENT 1 (BIOPHYSICAL ENV.)

- Potential Water Availability
  - Ratio of months with sufficient PWA
    - Precipitation
    - Evapotranspiration

$$Wetness\ Index = \frac{\text{Precipitation (mm)}}{\text{Potential ET (mm)}}$$

- Access to water
  - Ratio of population with the access
- Access to irrigation
  - Ratio of area with irrigation

COMPONENT 2 (AGRICULTURE)

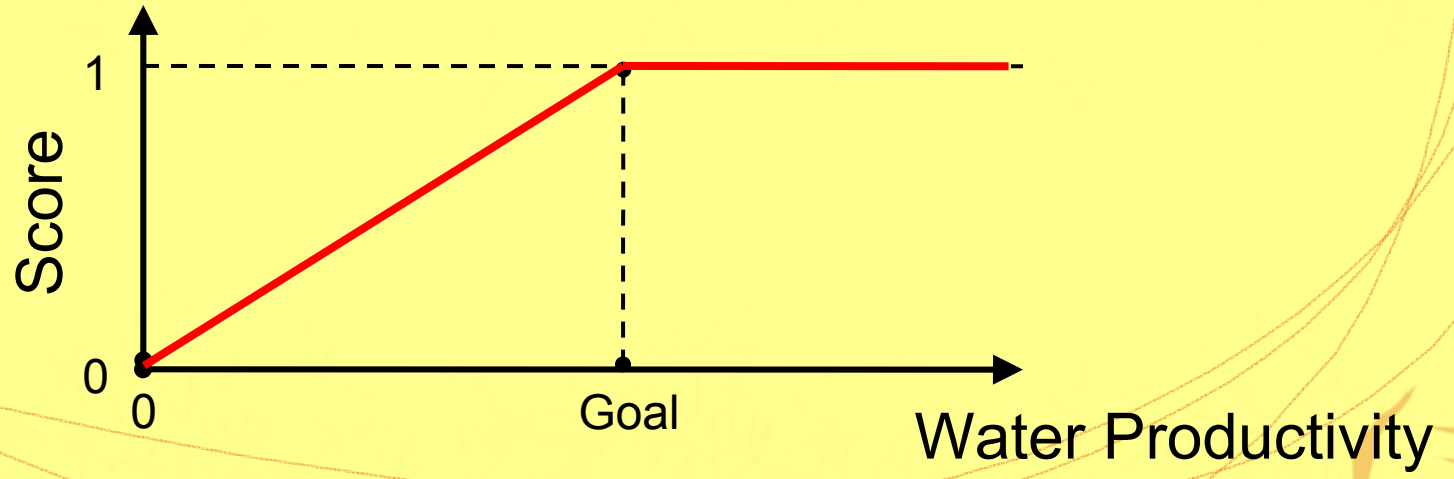
- Water Productivity
  - ➔Agricultural yields per water resources
    - Land use
    - Cropping pattern
    - Farming system
- Crop Suitability Index
  - Potato, beans, peas, wheat, barley, etc
  - ➔Crop-specific indices (climate, altitude, etc)

AGRICULTURE INDEX 1

- PWA-based approach

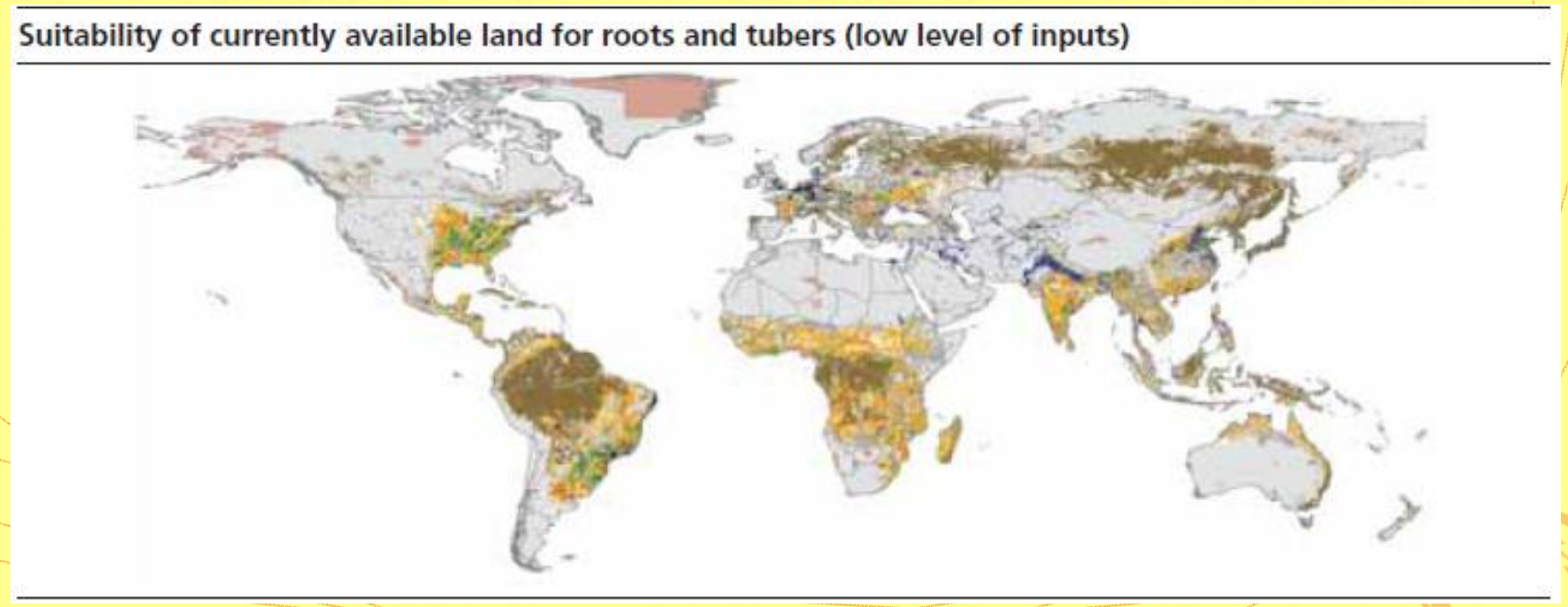
$$Water\ Productivity = \frac{\text{Crop production (ton/year)}}{WI}$$

$$I_{AGR} = \frac{\left(WP_{Goal} - WP_i\right)}{WP_{Goal}}$$



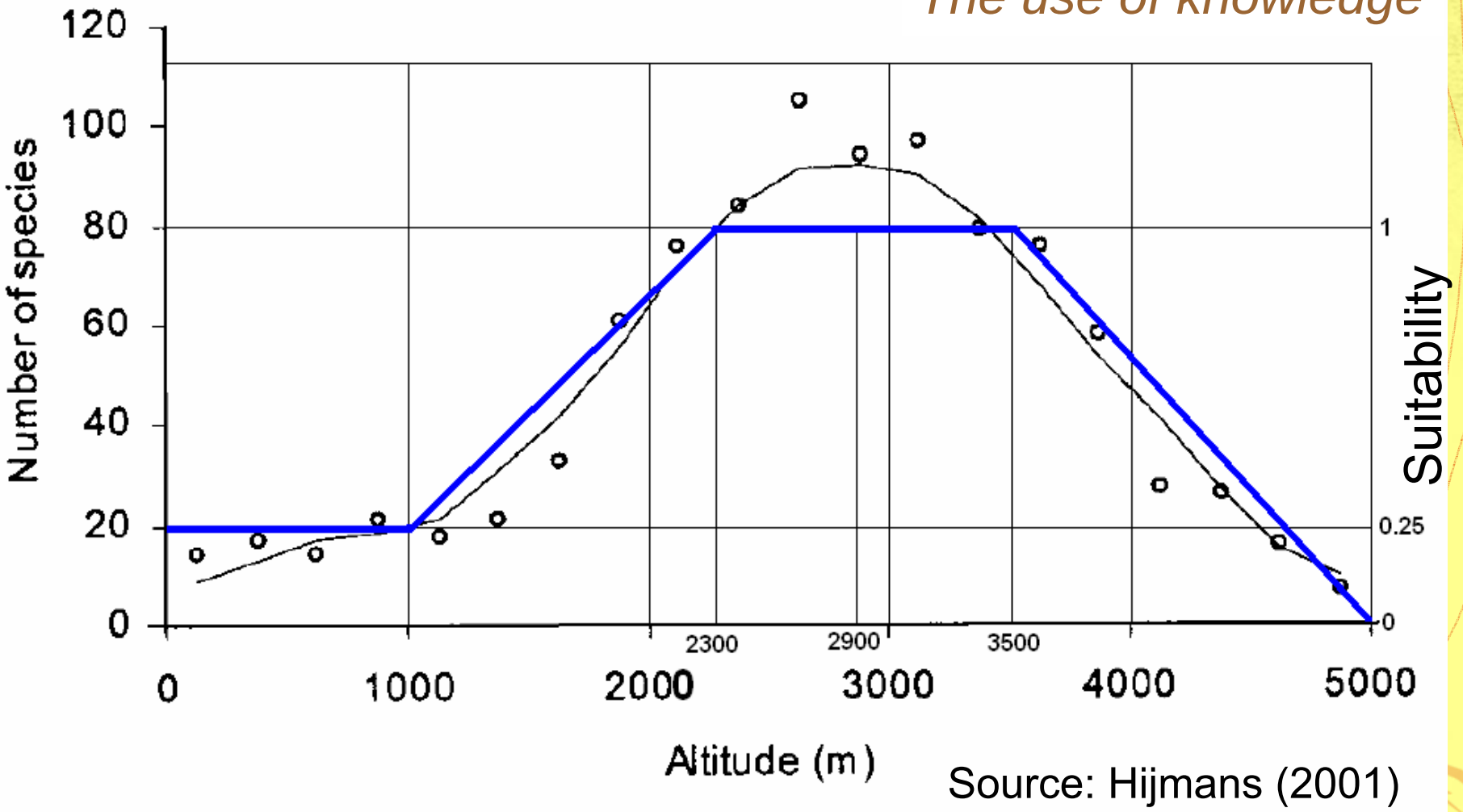
AGRICULTURE INDEX 2

- Crop suitability-based approach (FAO, 2007)
  - Soil, Slope, Air temperature.
  - Cropping pattern, growing season, etc.
  - GIS software is necessary...



CROP SUITABILITY EXAMPLE

The use of knowledge

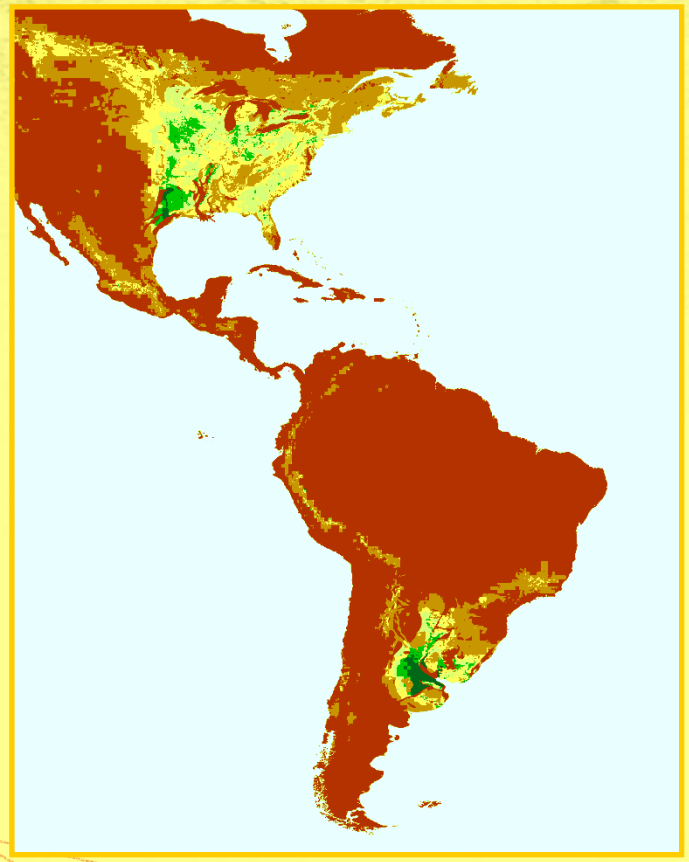


Source: Hijmans (2001)

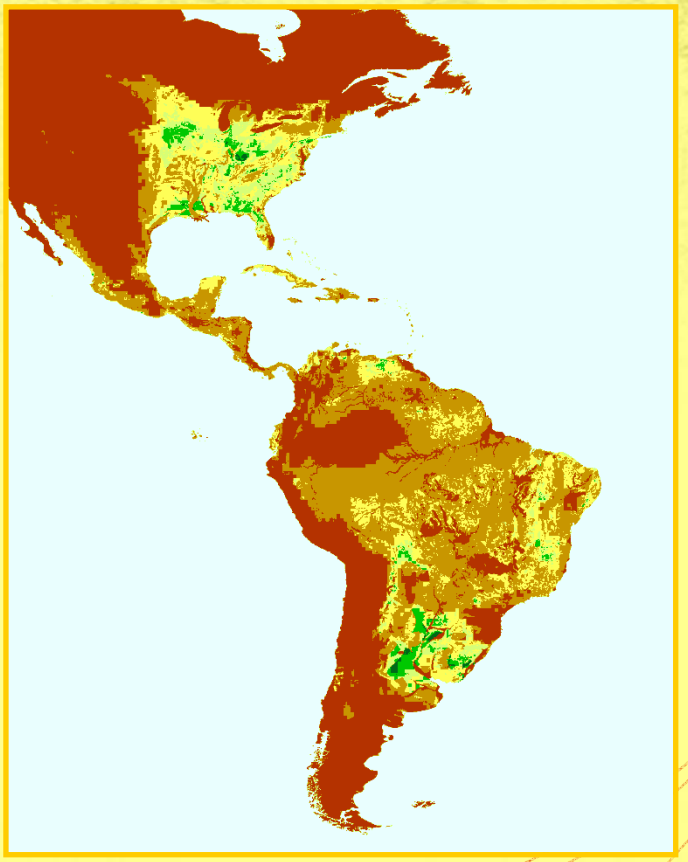
CROP SUITABILITY OUTPUT

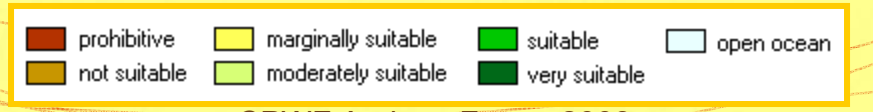
Source: http://www.fao.org/ag/agl/agll/cropsuit.asp

White Potatoes



Maize





COMPONENT 3 (SOCIO-ECONOMICS)

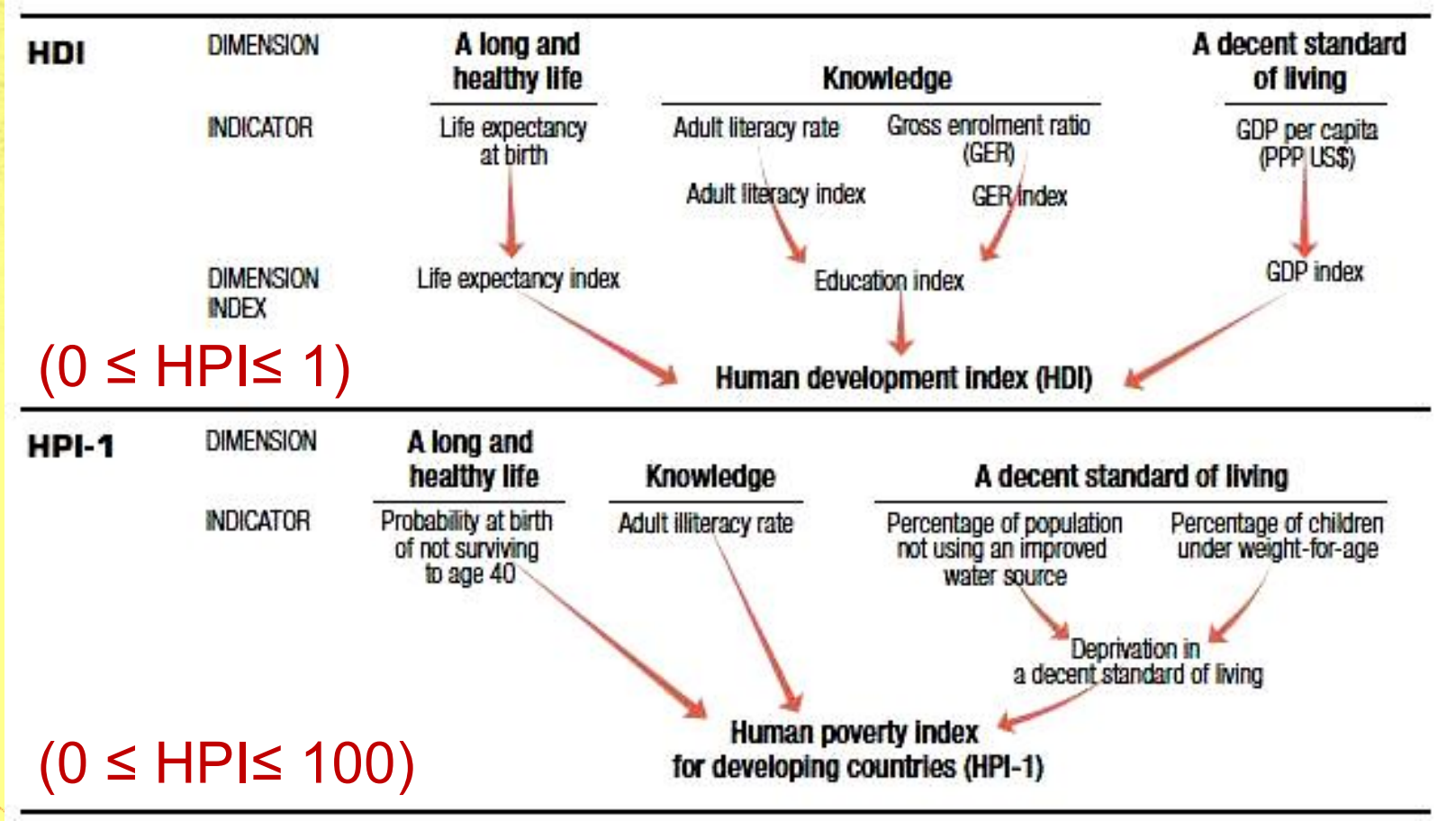
- HDI (Human Development Index)
- HPI (Human Poverty Index)
- Community-level, District-level, Country-level

♣ Additional information

- Income sources (agriculture, industry, others)
- Education (% enrolment, literacy rate, etc)
- Infrastructure (water & sanitation)
- Labour force

✓GDI (Gender-related Development Index)

INDEX BASED ON HDI & HPI



$$I_{SE} = \left\{ HDI \times \left(1 - \frac{HPI}{100} \right) \right\}^{1/2}$$

COMPONENT 4 (ECOSYSTEM)

- How to index?
  - Habitat suitability approach
  - Species composition
  - Expert knowledge-based approach

- Strongly dependent on each basin

  For instance,

  - Fuquene: Paramo (high land), Lake (low land)
  - Mojanda: Paramo including lakes (high land)

FUQUENE

- Paramo is affected by potato production
- Lake receives waste water (dom. & agr.)

MOJANDA

- Paramo provides water to all the people

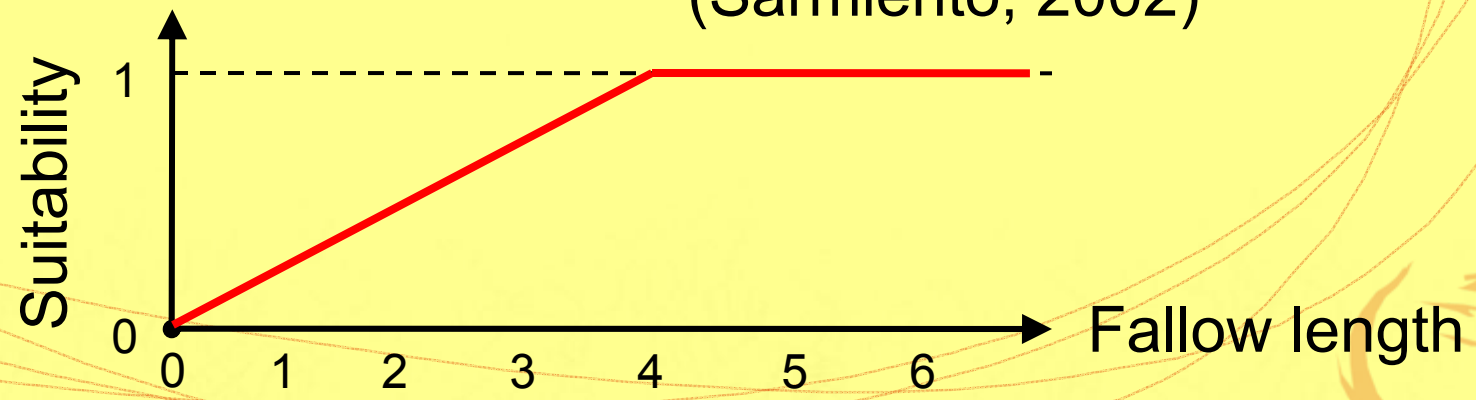
ECOSYSTEM INDEX

① $$I_{ECO,1} = \frac{\text{Actual Area of Paramo}}{\text{Potential Area of Paramo}}$$

② $$I_{ECO,2} = \frac{\text{Actual number of species}}{\text{Previously reportd number of species}}$$

③ ● The "***length of fallow period***" can be used as indicator for "***ecological status of paramo***."

➔ Paramo recovers after 4 or 5 yrs fallow (Sarmiento, 2002)



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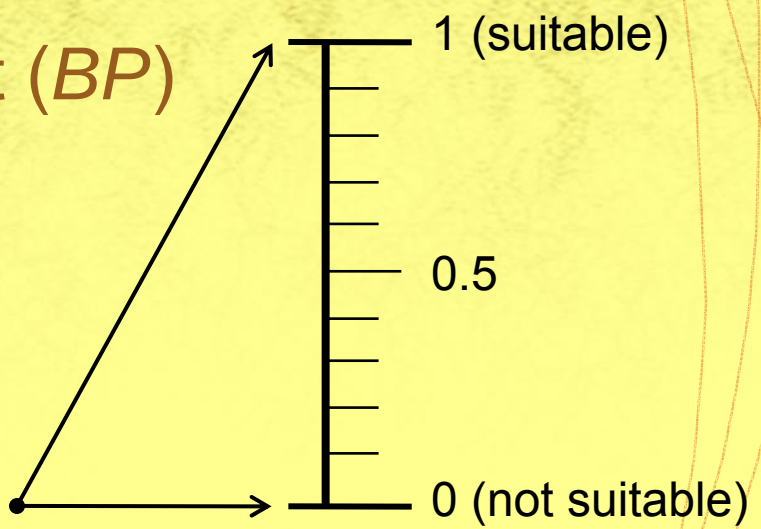

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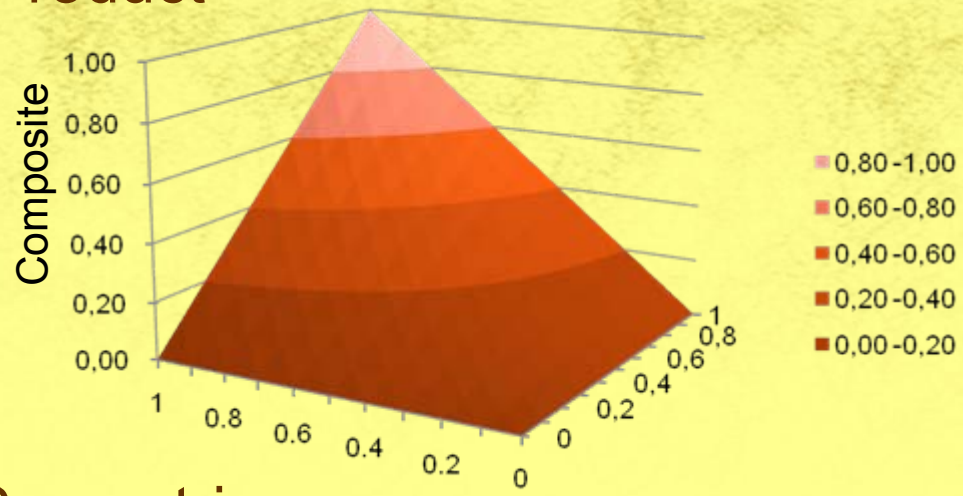
PRODUCT OR GEOMETRIC MEAN

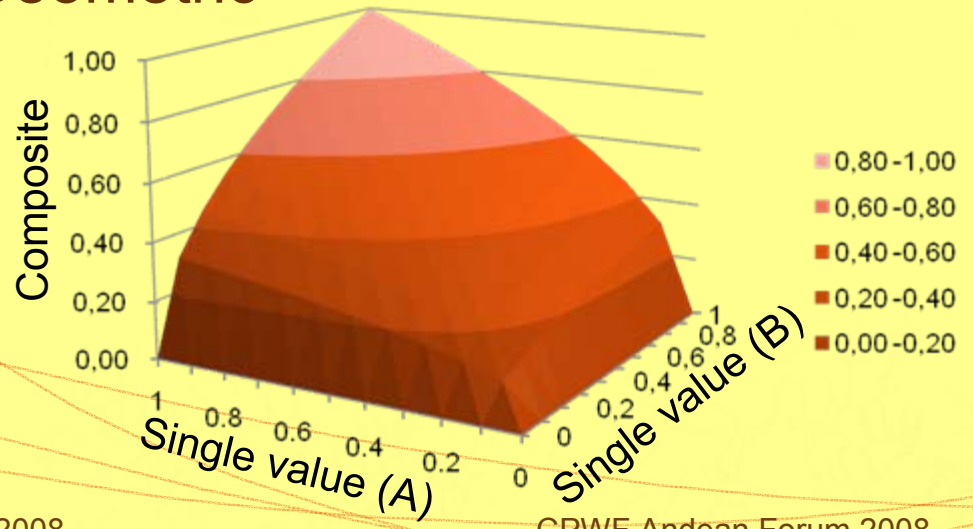
(1) Product



EXAMPLE

IF: A is bad
THEN: Totally bad

(2) Geometric



IF: A is bad,
but B is Good
THEN:
Totally acceptable
(***compensatory***)

HOW IT WORKS???

Sorry!!!
I could not prepare enough data
(community-level data at any basins)

➔ An example using country-base data
(Colombia, Ecuador, Peru, Bolivia, Chile)

- Assuming each country as towns in the basin...

✓ No agricultural & ecosystem analyses

➔ ***Can be done by using GIS software***

APPLICATION RESULTS (TOTAL)

Past status | Future Goals

Component	1995	2000	2005	2008	2010
Biophysics	0.42	0.45	0.47	0.45	0.47
Agriculture*	0.80	0.80	0.85	0.86	0.87
Socio-economics	0.818	0.832	0.842	0.88	0.90
Ecosystem*	1.00	0.90	0.80	0.82	0.85
TOTAL	0.724	0.721	0.720	0.727	0.748

BIOPHYSICS RESULT

Community	PWA	Irrigation	Water supply	TOTAL
Colombia	0.50	0.20	0.93	0.45
Ecuador	0.50	0.29	0.94	0.51
Peru	0.25	0.28	0.83	0.39
Bolivia	0.33	0.04	0.85	0.22
Chile	0.17	0.83	0.95	0.51
ALL	0.35	0.33	0.90	0.47

SOCIO-ECONOMICS RESULT (2005)

Community	Life	Education	GDP	HDI	1-HPI/100	TOTAL
Colombia	0.788	0.869	0.716	0.791	0.921	0.854
Ecuador	0.828	0.858	0.629	0.773	0.913	0.840
Peru	0.761	0.872	0.684	0.772	0.884	0.826
Bolivia	0.662	0.865	0.557	0.695	0.864	0.775
Chile	0.889	0.914	0.799	0.867	0.963	0.914
ALL	0.786	0.876	0.677	0.780	0.909	0.842

DISCUSSIONS

A Framework with general viewpoints

- Evaluation of Past & Present status
  - What is the achievement?
  - How much was it degraded?
  - Gaps between basins, communities, upstream & downstream regions, etc.
- Future Direction
  - Which sectors or communities should be strengthen?
  - What is the breakthrough?

➔ Specific analyses (e.g., SWAT, GT, etc)

DISCUSSIONS (CONTD.)

- Problem?
  - Availability of community-level data
  - Accuracy of measurement
  - Uncertainty (e.g. *lack of capacity assess*)
  - Acceptability among stakeholders
- Strength?
  - Generality across the basins
  - High accessibility to the data required
  - Easy to continue

FUTURE PERSPECTIVES

- What shall we do?
  - Further accumulation of data and information (monitoring)
  - Sharing experience & knowledge
    - Understanding of historical changes (quantitative & qualitative)
    - Evaluation of traditional agriculture (systems, techniques, varieties, etc)

AN EXAMPLE (QUALITATIVE BUT INFORMATIVE)

Gráfico Histórico

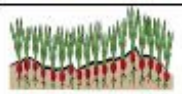
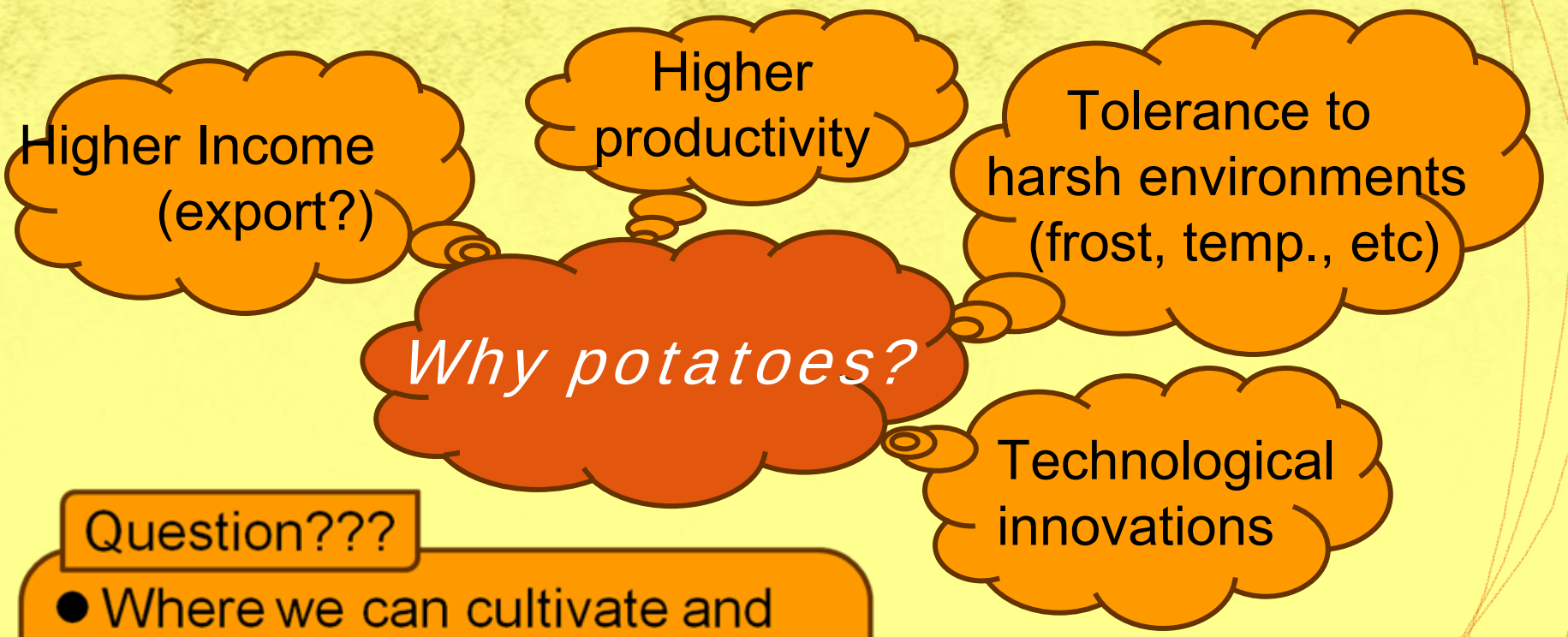
	1960	1970	1980	1990	2000-2004
Población Population					
Producción agropecuaria Agricultural Production	 Cultivos para el consumo, sin agroquímicos y diversificados	 Cultivos de papa y uso de agroquímicos. Cultivos de trigo y cebada	 Desaparecen los cultivos de cereales con el cierre del IDEMA, se incrementan los cultivos de papa y aumenta la ganadería	  Aumentan los cultivos de papa, la siembra de pastos y la ganadería	Aumentan los costos de producción de papa, se utilizan más agroquímicos, aumenta la ganadería, aumentan los cultivos de arveja, maíz y fríjol
Áreas de bosque y páramo Forest & Paramos	 Bosque nativo, frailejón, musgo	 Deforestación, extracción del bosque, uso de motosierras y tractores para preparar la tierra	 Reforestación con pinos y otras especies foráneas por parte de la CAR, disminución de bosque nativo.	 Agotamiento del suelo, erosión por causa del aumento de especies foráneas y cultivos de papa en páramo.	 Reforestación con especies nativas, conservación de áreas de páramo
Disponibilidad y calidad del agua Water issue: Availability & Quality	 Bastantes quebradas y ríos, abundancia de agua y buena calidad de la misma. No existían acueductos.	 Disminución del caudal de las aguas	 Disminución de agua, desaparecen quebradas, contaminación por incremento de agroquímicos y por las minas de carbón	 Se incrementa la contaminación, aumentan los acueductos, hay mal manejo de aguas residuales.	 Disminución considerable del agua, mayor contaminación. Conflictos por acceso al recuso.
Estado de la Laguna Status of Lake	Gran diversidad de fauna silvestre, agua pura, pocos juncos	Desecación, sedimentación causada por la contaminación. Invasión de áreas aledañas a la laguna	Aumenta la desecación y sedimentación, aumento de juncos. Aumento de la ganadería, traen el buchón para descontaminar el espejo de agua	Desaparece la fauna y los peces, aumenta el buchón y el junco. Disminuye el área de la laguna y se aumenta el área de pastos para la ganadería.	Contaminación, desecación, aumento de buchón y juncos.

Figura 40. Gráfico histórico, taller con Agricultores, Mayo 18 de 2004.

Source: GTZ, CONDESAN, CAR (2004)

There would be a question…



Question???

- Where we can cultivate and where we cannot?
- What is the best practice?

→Multi-disciplinary framework!!!